**Decision Making in Networks.**

**An Experiment on Structure Effects in a Group Dicator Game**

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Abstract:

In this study we examine the impact of communication networks on decision making in 5 person committees. Within the framework of a group dictator game the committees must reach a majority vote for one collective transfer. We focus on the effect of the group structure on the collective decisions, and explore the effect of incomplete and asymmetric information on voting outcomes by defining three different networks structures: the unconnected network, a circle and a star. As expected the connections lead to improved coordination within the committees. However, we find no significant difference between the network forms concerning the transfers chosen.

## 1. *Introduction*

Collective – or group – decisions are often made under the condition of incomplete and asymmetric information among group members. For example, a committee may be chaired by a person that has privileged access to information or a committee may consist of individuals who trust some but not all of the other committee members and hence share information only with a subset of the members.

Such settings can be considered abstract versions of a decision process repeatedly observed in policy networks. The European Commission, for example, often develops a directive in close cooperation with various lobby organizations that do not – or only very restrictively – share information among each other. Another setting is a situation in which non-governmental organizations (NGO's) involved in a policy process and considered one composite agent by other agents base their decision about their joint position within a larger actor constellation on information shared with a subset of friendly NGO's but not with others.

We restrict our analysis to decision-making in the context of problem solving (in contrast to spot contracts, distributive bargaining, and positive coordination; see Scharpf, 1997). This allows us to focus on the process of decision-making itself and to disregard issues of distributive justice.

In this study we examine the impact of communication networks on decision making in a highly controlled laboratory environment. We form groups of five anonymous subjects with the task to allocate a pie of 50 € between them and a second group of 5 people. If a majority voted for a certain allocation it was implemented whereas in case of no majority decision the proposer group earned nothing and the payoff for members of the receiver group was a random draw from a distribution of [0,5].

We implemented the decision task as a dictator game rather than a standard coordination game for three reasons. Firstly, the heterogeneous social preferences served as a device for generation intergroup conflicts. We know from several experimental studies that, typically, individuals show social preferences to a certain, but individually different extent (see, e.g., Blount, 1995; Fehr and Schmidt, 1999; Bolton and Ockenfels, 2000). Camerer (2003) reports average transfers in the range from 10 percent to 23 percent in several individual dictator games.

Secondly, the responsibility for a dependent party without entitlement appears to reflect the reality of political decision making in the context of problem solving better than the allocation of resources *within* the group of decision makers.

Finally, the common notion of a fair split might serve as a clue in the process of majority formation. This notion was repeatedly observed in experimental studies for example on the ultimatum game, where general transfers exceed 30 percent of the pie (e.g. Camerer and Thaler, 1995) with the equal split being the modal offer and recipients repeatedly reject transfers of less than 20 percent (Roth, 1995; Pillutla and Murnighan, 1995).

The main question to be answered in this paper is: Do collective decisions differ from this observed individual behavior? In other words, do equity- and reciprocity-oriented individuals change their behavior when they are part of a group?

Our examination of the communication structure differs significantly from previous studies on the effects of communication. In the realm of simple bargaining games the research on communication effects largely concentrated on the communication media (Roth, 1995; Brosig et al., 2003; or Luhan et al., 2008). A considerable, yet growing, body of experimental literature has examined the equilibrium choice in coordination games with a special particular focus on the impact of communication and learning in repeated interaction (see Ochs, 1995, for an overview).

In this paper, we focus on the effect of the group structure on collective transfer decisions. We explore the effect of incomplete and asymmetric information on voting outcomes by defining two different networks structures: a circle and a star (Bala and Goyal, 2000).

The paper is structured as follows: In the second section, the theoretical argument is presented. The third section details the experimental setup. In the fourth section, we report our findings and the fifth section concludes.

## 2. *Design, theory and hypothesis*

We model a decision-making group consisting of $n$ = 5 members. The core task of the group is a dictator game which was first introduced by Kahnemann et al. (1986) in an empirical study on fairness in the market place. In our model, the dictator group decides on the distribution of a stake $C$ between themselves and a second group of five recipients. The recipients group has no other option than to take whatever the dictator allocates to them, with every transfer being distributed equally amongst the group members.

As mentioned above, the actual task is only a framework for the group decision-making process which is the focus of our study. In the decision-making group every member has to decide individually on a transfer x of "her share" of the stake, $c= C/n$, with $x \leq c$. If a majority of at least three group members individually choose the same transfer $x$, this is set to be every group member's transfer and $X = n{\cdot}x$ is transferred to the recipients group. Irrespective of the individual choices, x is deducted from each member's initial endowment creating payoffs of

$$y_d = c - x \qquad (1)$$

for the members of the dictator group and

$$y_r = x \tag{2}$$

for each member of the recipients group.

If no majority emerges, the members of the dictator group receive no payoff while the recipients' payoff is drawn from a random distribution between zero and ten. In order to test the influence of communication networks on the group decision making process, we first designed a baseline treatment with an unconnected group (*nocom*).

In this treatment the members of the dictator group individually set their transfers without any means of coordination. If no majority is reached during the first attempt, the group members may choose transfers for a second time without any information on the previous choices of the other group members.

The predictions of standard game theory are straightforward: Purely selfish, profit maximising agents will individually set the lowest possible transfer of zero and this is the unanimous group decision. We therefore set our first Hypothesis accordingly.

Hyp. 1: All groups will unanimously decide on transfers of $X = 0$.

As noted above, this is challenged by models incorporating social preferences which are confirmed by experimental evidence on individual (see Camerer, 2003, for an overview), as well as on group dictator games (e.g., Cason and Mui, 1994; Luhan et al., 2008). In the framework of group decision-making without any coordination, the assumption of heterogeneous social preferences leads to multiple equilibria. Without any priors on the distribution of social preferences within the group (hence a uniform distribution), the group members will simply set their preferred transfer and majority decisions on any of the given possible transfers can occur. With the given probability of $7.25 \times 10^{-6}$, however, the occurrence of a majority decision is unlikely under this assumption.

According to the model proposed by Fehr and Schmidt (1999), there are two possible equilibria, a “very fair” one at $x$ = 50 percent and a “very unfair” one at $x$ = 0 percent in the individual dictator game. In our context, these equilibria serve as focal points for possible transfer choices.

Depending on an agent’s beliefs about the distribution of “fair” and “selfish” types amongst the group members and her social preferences she will choose either one of these transfers. Even without prior information about the other group members each of these transfers will lead to a majority decision with a probability of 50 percent. We claim that irrespective of the individual social preferences, each member of the dictator group will choose the transfer she believes to be most likely to be chosen by at least two other group members, as any transfer other than the majority-compatible one will most likely result in a payoff of zero. A selfish agent in a mostly “fair group” will therefore choose a transfer of 50 percent as other transfers are irrelevant or will even reduce the probability of a positive payoff. A fair agent in a mostly selfish group will on the other hand only choose a transfer of 50 percent if she is willing to sacrifice her payoff of 100 percent to generate an expected payoff of (the smallest increment more than) 25 percent[1] for the members of the reiceiver group, which is an unrealistic assumption according to Fehr and Schmidt (1999).

When considering social norms, the equal split remains as the only focal point of coordination. The ‘Social Comparison Theory’ described by Cason and Mui (1994) states that subjects try to present themselves in a way that is socially desirable. In absence of any information on the distribution of social preferences the probability of 50 percen transfers exceeds the probability of 0, confirming 50 percent as the focal point of coordination. Again, this focal point is found as the modal choice in Ultimatum games, where selfish agents strategically choose fair transfers in order to maximize their expected payoffs. Even selfish agents, unaware of the distribution of social preferences within their group, will choose this transfer as it maximizes the probability of a majoritarian choice.

[1] The payoff for the receivers was defined randomly as any amount between 0 and 5 in steps of 0.1. The expected payoff from a random distribution [0,5] in steps of 0.1 equals 2.55.

Hyp. 2: In absence of prior information about the distribution of social preferences within the dictator group, the equal split of 50 percent will maximize the probability of a majority vote.

But the setting of an unconnected network as a decision making group is most unrealistic and serves only as a reference point. Communication channels of various forms can be found in any political context, either structured or unstructured. As we try to examine the basic effects of communication networks in group decision making, we want to exclude any effects of the actual communication channels used and refrain to a very limited and strictly structured form of communication. In our setting the members of the dictator groups can only make one proposal for the group transfer before the actual transfer choice. This proposal is purely numerical and serves as an indicator of the transfer that the respective subject is willing to choose. The actual structure of the network then defines which other group members will be informed about the respective proposal.

We model two network structures, a star-shaped network with one central group member (*star*) – as depicted in Figure 1 – and a circular network (*circle*) – as depicted in Figure 2.

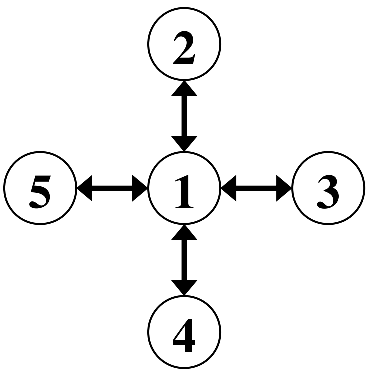

**Figure 1: star shaped network**

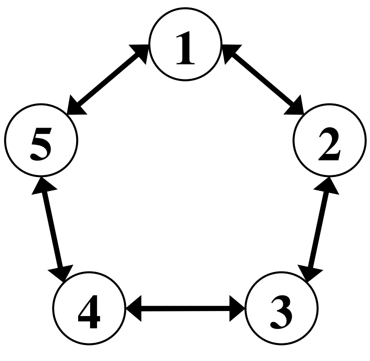

**Figure 2: circular network**

In the star-shaped network, only the central member (member 1) can see all proposals and only her proposal is visible to all other group members.

Schelling (1960) describes the impact of any commonly observed information and claims that this information can make any equilibrium a focal point. In our setting, the commonly observed information is not exogenously given, but a part of the actual decision process. Therefore the only equilibrium choice in the star treatment is the proposal of the central member. Not only does her choice constitute 33 percent of a possible majority but also this proposal is the only possible point of coordination since it is commonly observed.

> Hyp. 3: In the star-shaped network, the central member's choice is the equilibrium/majority choice.

The central agent, in turn, is not bound to the above-described focal points. Aware of her special position, the central agent can choose her proposal and subsequent transfer according to her individual (social) preferences. Though she observes all proposals from her group, she is bound to stick to her initial proposal because otherwise the coordination effect of the commonly observed proposal would be destroyed.

> Hyp. 4: Central members will not be influenced by the other group members' proposals.

We cannot form an *a priori* hypothesis on whether the star shaped networks will increase or decrease the group transfers as this is subject to the social preferences of the central group members. But we do expect this network structure to significantly increase the number of majority decisions in the course of the experiment.

> Hyp. 5: Star-shaped-network groups will reach majority decisions more frequently than unconnected groups.

The second network structure we examine is a circular network as depicted in figure 2. Here the proposals as well as the actual transfers are only observed by the immediate neighbours in the network. Each agent is informed about the proposals and transfers of the agents located to her left and right. This, on the one hand, provides every agent with information about a subgroup large enough to potentially cast a majority vote on their own. But, on the other hand, both neighbours observe the actions of one agent out of this subgroup. Therefore even if an agent observes three identical proposals she cannot take this as a secure sign for a majority vote as her neighbours might observe very different proposals and therefore choose a transfer differing from the initial proposal. Coordination or compromising on this information subset of three proposals might therefore not be a successful strategy. The extreme case would be that the group members do not take the proposals as valid information and retreat to the focal point of the unconnected groups. We therefore form two antithetic hypotheses (6 and 7) for the circular network.

Hyp. 6: In the circular network, the observed proposals will have a significant impact on the individual transfer choice.

If we apply the same reasoning as in the case of unconnected groups that agents may choose any transfer size with equal probability, the chance that a situation occurs in which both received proposals are identical with the one sent is very small. Hence information obtained in a circle is of little value because no agent can trust that others will stick to their proposal. Consequently in the absence of reliable information, the outcome should approach the uninformed and unconnected baseline situation.

Hyp 7: In the circular network, the equal split is the equilibrium/majority choice. The observed proposals will have a no impact on the individual transfer choice.

## 3. Experimental procedure

We implemented the above described decision task computerized using z-Tree (Fischbacher, 2007) in the MSW-Lab at the University of Oldenburg. Participants were recruited in groups of twenty from the students of all faculties of the University. Two sessions were run for each treatment (*nocom*, *star*, *circle*), creating eight group observations for the *nocom* and the *star* treatment and seven for the *circle* treatment (one session consisted of only fifteen participants due to low show up).

Upon arrival, the subjects were seated randomly at computer carrels that prevented communicating or seeing the screens of the other players. Instructions were distributed in paper form and a recording of the instructions was played to assure standardized conditions and common information. Subjects were informed about the details of the respective treatment and the communication structure (or the absence of communication). The experimental currency was "points" and the official rate of exchange was two Euros per point. So in the lab setup the endowment of the group $C$ was 25 points and an equal split transfer was $x = 2.5$.

We used a one-shot setup with a single decision task (two trials for the formation of a majority). An experiment lasted ten minutes on average. After the experiment the subjects filled in a short questionnaire, were paid privately in cash and were released.

## Results

**Table 1: Group transfers and first proposals**

| Treatment | N | Groups | Majority | Group transfer | | First proposals | |
|---|---|---|---|---|---|---|---|
| | | | | Mean | SD | Mean | SD |
| *nocom* | 40 | 8 | 3 | 2. 500 | 0.000 | - | - |
| *star* | 40 | 8 | 8 | 1.063 | 1.130 | 1.043 | 0.971 |
| *circle* | 35 | 7 | 7 | 1.929 | 0.534 | 1.671 | 0.870 |

As expected, the decision task was "hardest" in the *nocom* treatment. The column labeled "Majority" contains the numbers of groups that managed to form a majority in the first or second attempt. Out of the eight groups in the nocom treatment, only three reached a majority decision, one of those only in the second run. These results reinforce our Hypothesis 5: Only 37.5 percent of the *nocom* groups reached a majority decision, whereas 82 percent of the groups accomplished this in the first attempt of the *star* treatment and still 71 percent in the first attempt of the *circle* treatment. We can reject our first Hypothesis in favor of the second as all three observed group transfers in the *nocom* treatment were 2.5 points (or 5 Euros).

The group transfers in the *nocom* treatment are therefore significantly higher than those in the *star* (Man-Whitney-Test $p = 0.052$) and in the *circle* treatments ($p = 0.064$). However, the group transfers in the two network structures are not significantly different from each other.

Looking at the proposals of the central subjects in the *star* networks (member 1) we find that their average proposal (1.063) did not differ significantly ($p > 0,8$) from the proposals of the other group members (1.038). Assuming that the central members were aware of their privileged position, this confirms, on the one hand that these subjects are not different from the rest of the population. On the other hand, we find that the central network position did not cause behavioural differences in the first place. So all the proposals from central group members appear to reflect the true preferences of these agents. The effect of these 'central' proposals is quite striking: Of all 32 remaining subjects, only three proposed the same transfer as the central subject of their respective group, 53 percent proposed a higher and 38 percent a lower transfer than the central agent. In the following decision stage, however, 81 percent[2] of all members entered a transfer equal to the proposal of the central member, which is a clear confirmation of Hyp. 3.

[2] This number increases to 86 percent if we examine only those 7 groups of the star treatment, which reached a majority in the first Period.

Though the centralized proposal is working as well as theoretically predicted, 50 percent of the central subjects did not re-enter the transfer they proposed in the decision stage, leading to a rejection of Hyp. 4.[3]

In the *circle* treatment we found the proposals entered to be significantly higher than those in the *star* treatment ($p < 0.05$). In the *star* treatment, the modal proposal of 2.0 was sent by ten of the 40 subjects, whereas 65 percent of the agents chose a proposal of 1.0 or lower. In the *circle* treatment, eleven subjects sent the modal proposal of 2.5 and still ten subjects sent a proposal of 2.0. This observed trend towards the equal split in the circular network is in line with Hyp. 7, though not confirming it.

Table 2 contains the estimation results for the transfers chosen in the *circle* treatment conditional on the subjects' own proposal as well as on the respective neighbours' proposals. We start with the basic linear model reported in column 1 of Table 2. We test for heteroskedasticity and omitted variables but can reject both. Using the Ramsey RESET-test for misspecification we rejected the possibility of non-linear combinations of the independent variables. The reported logarithmic transformation of dependent and independent variables did not improve the quality of the estimation.

Unsurprisingly, we find the own proposal to have the largest impact on the transfer choice. However, the coefficients of the neighbours' proposals are highly significant and their joint influence on the transfer is equally strong as the own proposal. The large coefficient of the own proposal could be interpreted as partial adherence to the personal preference despite possibly contrary proposals from the neighbours. But this coefficient could also be interpreted as the attempt to equal out the observed diversity of observed proposals. The high rate of successful majority formations at the first attempt (six out of seven groups) fosters the latter interpretation. This leads us to reject our Hypotesis 7 and to affirm Hypothesis 6.

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[3] In one group the inconsistent actions of the central member actually was the reason for the failure to form a majority in the first attempt.

Examining other potential factors we do not find a gender effect but a moderate influence of the subjects' age.

**Table 2: Estimation circular network**

| Dependend Variable | *transfer* | *transfer* | *ln(transfer)* | *ln(transfer)* | *transfer* |
|---|---|---|---|---|---|
| **Model** | **1** | **2** | **3** | **4** | **5** |
| signal | 0.590*** | 0.589*** | 0.746*** | | |
| | (8.47) | (8.59) | (6.69) | | |
| gender | -0.039 | | | | |
| | (0.34) | | | | |
| age | 0.020** | 0.020** | 0.031** | | |
| | (2.57) | (2.59) | (2.52) | | |
| proposal1_neighbor1 | 0.233*** | 0.236*** | 0.078 | | |
| | (3.57) | (3.70) | (0.76) | | |
| proposal1_neighbor2 | 0.321*** | 0.320*** | 0.313*** | | |
| | (4.99) | (5.06) | (3.14) | | |
| lnproposall | | | | 0.624*** | 0.452*** |
| | | | | (7.73) | (6.22) |
| lnage | | | | 0.573* | 0.224 |
| | | | | (1.86) | (0.81) |
| lnprop.1_neighbor1 | | | | 0.191** | 0.255*** |
| | | | | (2.75) | (4.07) |
| lnprop.1_neighbor2 | | | | 0.196** | 0.193*** |
| | | | | (2.69) | (2.95) |
| Constant | -0.736** | -0.757** | -2.426*** | -1.749* | 0.803 |
| | (2.56) | (2.73) | (5.17) | (1.74) | (0.89) |
| Observations | 35 | 35 | 34 | 32 | 32 |
| AIC | 0.64 | 0.59 | 1.50 | 1.00 | 0.79 |
| BIC | -92.74 | -96.15 | -61.42 | -71.61 | -78.41 |
| Adjusted $R^2$ | 0.84 | 0.85 | 0.68 | 0.78 | 0.77 |

Absolute value of t-statistics in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

In a similar vein, we model the individual transfers in the *star* treatment as a function of the own proposal, the proposal of the central member as well as age and gender of the subject (table 3). As expected, the proposal of the central member (proposal_1) is decisive for the transfers of all group members, thereby providing further evidence in favor of Hypothesis 3. We find that the best specification is again a linear regression with only the own proposal and the proposal of the central agent as explanatory variables. Still, the influence of the own proposal is only a minor one and might as well be neglected, as displayed by the BIC-statistics.

**Table 3: Estimation star shaped network**

| Dependend Variable | *transfer* | | | | |
|---|---|---|---|---|---|
| **Model** | **1** | **2** | **3** | **4** | **5** |
| proposal | 0.222* | 0.225** | 0.178* | 0.183* | |
| | (1.95) | (2.11) | (1.94) | (2.02) | |
| gender | 0.022 | | 0.069 | | |
| | (0.09) | | (0.30) | | |
| age | -0.013 | -0.014 | | | |
| | (1.46) | (1.59) | | | |
| proposal_1 | 0.710*** | 0.709*** | 0.734*** | 0.731*** | 0.710*** |
| | (5.80) | (6.03) | (6.36) | (6.58) | (6.05) |
| Constant | 0.243 | 0.266 | -0.117 | -0.076 | 0.136* |
| | (0.93) | (1.60) | (0.64) | (0.68) | (1.76) |
| Observations | 32 | 32 | 32 | 32 | 32 |
| AIC | 1.96 | 1.90 | 1.92 | 1.86 | 1.89 |
| BIC | -44.94 | -44.40 | -43.63 | -46.98 | -47.63 |
| Adjusted $R^2$ | 0.61 | 0.63 | 0.62 | 0.63 | 0.61 |

Robust t-statistics in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

## 4. Conclusion

In this paper we studied the impact of different communication network structures on group decision making. The decision task was modelled as a group dictator game as in our view this reflects the intra group conflicts that a heterogeneous committee might face as well as the motivational structure of preferences and responsibilities for a third party that is at the core of political decision making in the problem-solving mode.

We compared unconnected groups that had no possibility to communicate for coordination with a star-shaped network with one central, commonly observed member and a circular network where communication was possible only with the immediate neighbours.

As expected, both network types increased the rate of successful decision making significantly. Both network structures produced a 100 percent success rate of majoritarian decisions. In the *star* treatment, the group decisions ar solely driven by the central agent. Whatever proposal this agent makes is subsequently adopted as a group decision. Groups even formed a majority in the occasions that the central agent changed the proposed transfer amount between the proposal phase and the decision phase by following the accidentally identical proposal of two peripherical agents.

The information provided for coordination in the circular network is less efficient and correctly evaluated as such by the subjects. Therefore the proposals made approach the equal split, analogous to the groups without any information. This trend towards the socially accepted transfer of 50 percent of the pie appears to be the reason for the high rate of successful coordination attempts and majority decisions in the circular treatment. When actually confronted with the information, however, subjects do use this information to attempt to coordiate within this subgroup.

## 5. References


Bala, Venkatesh, and Sanjeev Goyal (2000): A Noncooperative Model of Network Formation. *Econometrica* 68, 1181-1229.

Blount, Sally (1995): When Social Outcomes Aren′ t Fair: The Effect of Causal Attributions on Preferences. *Organizational Behavior and Human Decision Processes* 63, 131-144.

Bolton, Gary, and Axel Ockenfels (2000): “ERC: A Theory of Equity, Reciprocity, and Competition,” *American Economic Review* 90, 166–193.

Brosig, Jeanette, Joachim Weimann, and Axel Ockenfels (2003): The Effect of Communication Media on Cooperation. *German Economic Review* 4. 217-241.

Camerer, Colin (2003): *Behavioral Game Theory: Experiments in Strategic Interaction,* Roundtable Series in Behavioral Economics, Princeton University Press, Princeton.

Camerer, Colin and Richard H. Thaler (1995): Anomalies: Ultimatums, Dictators and Manners. *Journal of Economic Perspectives* 9, 209-219.

Cason, Timothy and Vai-Lam Mui (1997): A Laboratory Study of Group Polarization in the Team Dictator Game. *Economic Journal* 107, 1465-1483.

Fehr, Ernst and Klaus M. Schmidt (1999): A Theory Of Fairness, Competition, and Cooperation, *Quarterly Journal of Economics* 114, 817-868.

Kahnemann, Daniel, Jack Knetsch, and Richard Thaler (1986): Fairness as a Constraint on Profit Seeking: Entitlements in the Market. *American Economic Review* 76, 728-741.

Luhan, Wolfang J., Marting G. Kocher and Matthias Sutter (2008): Group Polarization in the Team Dictator Game Reconsidered. *Experimental Economics. forthcoming.*

Ochs, Jack (1995): Coordination Problems, in John Kagel and Alvin E. Roth (eds.): *Handbook of Experimental Economics*. Princeton University Press, Princeton, 195-251.

Pillutla, Madan .M. and J. Keith Murnighan (1995): Being Fair or Appearing Fair: Strategic Behavior in Ultimatum Bargaining. *Academy of Management Journal* 38, 1408-1426.

Roth, Alvin E. (1995): Introduction to Experimental Economics, in John Kagel and Alvin E. Roth (eds.): *Handbook of Experimental Economics*. Princeton University Press, Princeton, 3-109.

Scharpf, Fritz W. (1997). *Games Real Actors Play. Actor-Centered Institutionalism in Policy-Research*, Boulder: Westview Press.

Schelling, Thomas (1960). *The Strategy of Conflict.* Harvard University Press, Cambridge.